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# BIOLOGICAL BULLETIN.

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## ABNORMALITIES IN THE CESTODE *MONIEZIA* EXPANSA. II.

C. M. CHILD.

### I. *Spiral Abnormalities.*

IN the cases described in this section spiral modifications of the segmentation are present in greater or less degree. Associated with these are often found examples of partial division resembling those described in Part I, *Biological Bulletin*, Vol. I, No. 5. Where these are closely connected with the spirals they are shown in the figures and briefly described.

Figs. 24, 26, 27, 30, 38, 39, are selected from a number of different individuals. The other figures are all taken from the single worm mentioned in Part I as possessing a very large number of abnormalities. Figs. 34 and 35, being taken from a point nearer the anterior end of the chain, where the size is much less than in older proglottids, are magnified about fifty diameters, the other figures about twenty.

For terms used in the description, the structure of the normal segment, etc., the reader is referred to the first paper (*Biol. Bull.*, Vol. I, No. 5).

#### *Figure 24.*

The principal feature of this figure is a case of partial division, which is in reality a short spiral. The proglottid *a* shows at the right a very short furrow extending from the edge a short distance over the upper surface and ending free.

The lower surface shows no corresponding furrow. The length of the proglottid at this side is somewhat greater than, but not double, the normal length, *i.e.*, it is not as long as two fused proglottids of the same age. Two groups of cells, the "Anlagen," of the reproductive organs or "genital masses," appear upon this side, however, as would be the case if the short partial furrow were complete. The furrow itself indicates the imperfectly double character of the segment, and the two genital masses show this still more clearly. At the left *a* is only half as long as at the right and possesses only a single genital mass. The partial segment *b* is completely separated from *a* both on the upper and lower surface, but is seen to be

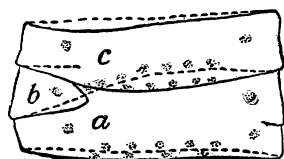


FIG. 24.

connected with *c* on the lower surface. The furrow separating *b* from *a* runs inward and somewhat anteriorly from the left edge for about one-third the width of the body, then turns and extends outward and anteriorly until it joins the complete furrow in front.

Thus the small piece *b* is completely marked off on the upper surface, and though its edge at the left side is of normal length, it narrows to a rounded end. On the lower surface the relations are different, for the partial furrow between *b* and *c* on this surface ends free, while the complete furrow separating *a* and *c* at the right bends so as to pass posteriorly to *b* at the left and connects at the left edge with the furrow between *a* and *b*. The partial segment *b* is thus a short spiral, making less than half a turn. Notwithstanding its small size, it shows a genital mass as large and distinct as any at this stage.

Figure 25.

Here two examples of partial division and a short spiral occur. Upon the upper surface the two partial proglottids *a* and *b* are incompletely separated, the partial furrow on the left side being longer than that on the right. The partial furrows at the right correspond exactly on the two surfaces, both ending free. The partial furrow on the upper surface at the left forms

the beginning of a spiral furrow which makes one and a half turns. It is oblique upon the lower side, running from between *a* and *b* at the left to the anterior edge of *b* at the right, then passing over the upper surface again as a complete transverse furrow anterior to *b*, and finally ending free on the lower surface. Thus the spiral segment *b* is open at both ends. If the furrow between *a* and *b* on the upper surface were complete, the spiral would begin between *a* and *b* at the right on the lower surface, and the furrow would thus make almost two turns. In the region where the genital masses appear the furrows show very nearly normal relations, and the position of the genital masses needs no comment.

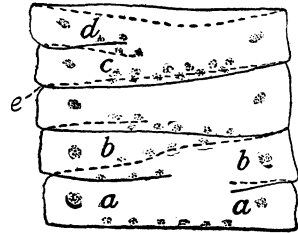


FIG. 25.

In *c d* another case of simple partial division occurs at the left, the partial furrow corresponding in position on the two surfaces. At the left two genital masses occur, while at the right, where *c d* is undivided and shorter than at the left, only one appears. All the partial furrows which extend far enough from the edges to lie within the region where the interproglottidal glands occur, possess them. The furrows between *a* and *b* on the right show none, as they are too short.

*Figure 26.*

This case consists of a short spiral in which the spiral furrow makes one and a half turns about the body. As the result of its course the partial proglottid *b* is formed, which unites on the upper surface with *a*, and on the lower with *c*.

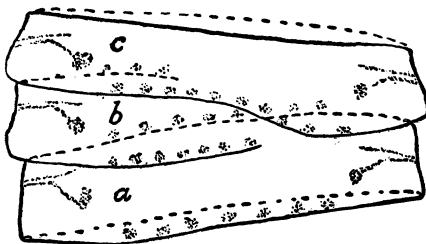


FIG. 26.

In the lateral regions the segmental boundaries are all normal, and, accordingly, the organs are situated nor-

mally, but at the left there are three segments and at the right only two, and a corresponding number of sets of genital organs is found.

*Figure 27.*

A spiral furrow making only a little more than half a turn appears in this case. At the left the upper surface of *a* is united at the edge with the lower surface of *b*, and at the right the lower surface of *a* unites at the edge with the upper surface of *b*.

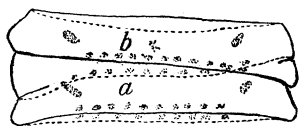


FIG. 27.

The only abnormality visible at this stage in the genital organs appears at the left in *a*. Here the genital "Anlage" is elongated and narrower than in the other cases. The proglottid is not sufficiently developed to show the ducts and pores, so that it is impossible to determine just what the situation of these organs will be.

*Figure 28.*

Here the natural relation of the dorsal and ventral surface is somewhat altered. The figure is drawn with the dorsal surface uppermost, and it is seen that the furrows on the dorsal surface lie further posteriorly than those corresponding to them on the ventral surface. The furrows bounding *a* posteriorly do not meet at the edge, as they would if normal and merely distorted by pressure or otherwise, but the end of the ventral furrow is anterior to the dorsal. The furrows *d* and *d'* would correspond to each other if normal, but as a matter of fact *d'* meets *e* at the left edge instead of meeting with its corresponding furrow *d*, thus producing a slight spiral. The furrows *e* and *e'* would meet at the two edges if normal, but here again the ventral furrow is considerably anterior to the dorsal except at the right edge, and its left end shows no indication of bending posteriorly to meet the latter. A somewhat similar condition is seen frequently in mounted specimens, but in most cases is simply a distortion due to the compression between glass plates during fixation. The real abnormalities such as occur

here can be distinguished by the fact that at one edge or the other or both the corresponding furrows on the two surfaces do not meet. That some distortion has also occurred in this case is probable from the fact that in the regions immediately outside and posterior to that of the figure otherwise normal segments are oblique dorso-ventrally, as if the dorsal surface had moved posteriorly over the ventral, or the ventral anteriorly over the dorsal. The segment *b* is bounded by a furrow beginning at *d''* and forming a spiral of nearly two turns, ending free on the ventral surface (*e'*). The genital organs *b'*, on the left side of *b*, lie almost between the dorsal furrow *e* and the ventral *d'*, and it is the only genital mass on the left for the whole spiral. The ovary and vitellarium, being nearer the ventral surface, appear between the furrows *d'* and *e*, while the ducts lying nearer the dorsal surface bend posteriorly, and their terminal portions appear posterior to the furrow *e* on the dorsal surface, and finally reach the surface almost midway between the dorsal furrows bounding *b*. At first glance it ap-

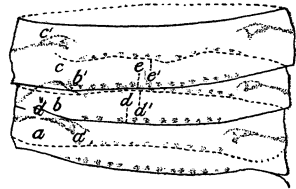


FIG. 28.

pears that if the position of the genital organs is correlated with the form of the proglottid, the duct should open somewhere in the region *c* instead of passing posteriorly under the dorsal furrow *e*, as it does. As a matter of fact, however, its position is the only one possible in the spiral proglottid *b*. Since the spiral segment *b* lies somewhat obliquely, *i.e.*, with its ventral surface somewhat anterior to the dorsal, the position of the organs at *b'* between the dorsal furrow *e* and the ventral *d'* is only apparent. In reality they are in about the normal position in their segment *b*. The outer end of the ducts is rudimentary, consisting of a scarcely visible strand of cells, and there is no enlargement in the region of the pore. Moreover, the inner end of the vas deferens instead of running anteriorly to the ovary and vitellarium, as is usual, is posterior to them, as seen in the figure (*b'*). This position of the inner end of the vas deferens posterior to the ovary is peculiar and is probably due to the oblique position of the segment *b*.

The rudimentary character of the terminal portion of the ducts is apparently due to the fact that the proglottid *b* is not wholly distinct from *a* in this region. The posterior dorsal furrow is interrupted at *d''*. The short portion extending to the left edge is not a furrow of normal depth but a scarcely visible fold upon the surface, and the left end of the main furrow at *d''* is also very shallow. On the ventral side there is no furrow corresponding exactly to the furrow *d'd''*, for *d'* is a spiral continuation of it. Therefore the only evidences of separation between *a* and *b* in this region are the slight furrows at *d''*. Since the degree of separation is so slight, the tendency to form a second genital pore and the terminal region of the ducts is probably very slight also, but is still present, as is evident from the figure. The testes are just beginning to appear (not represented in the figure), and their distribution corresponds exactly with the conditions on the dorsal surface.

*Figure 29.*

At the stage shown here the proliferating groups of cells forming the reproductive organs are visible, and the interproglottidal glands are more numerous. The variation is a spiral, the furrow making two complete turns. The posterior end of the spiral furrow appears between *a* and *b* at *e*. Upon the lower surface it is a complete furrow and is continuous with the furrow upon the upper surface between *b* and *d*. This bends anteriorly at the left instead of completing the furrow between *b* and *a*, and so separates *b* and *c* at the left edge,

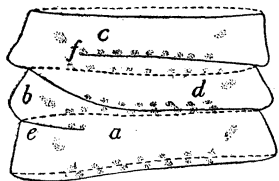


FIG. 29.

continuing over the lower surface as a complete furrow and passing once more to the upper surface between *d* and *c* at the right and finally ending free at *f*. The only portion of this continuous furrow which differs greatly in position from the normal is the part between *b* and *d* at the left on the upper surface, where it bends anteriorly and so fails to complete the separation between *a* and *b*. The spiral is the result of this bend

in the furrow, but since the furrow ends free at *e* and *f* both ends of the spiral proglottid bounded by it are open and connect respectively with *a* and *c*. The position of the genital masses is not affected by the presence of the spiral arrangement.

The general relation of the inter-proglottidal glands to the furrows is shown by the fact that the glands appear with the abnormal and partial furrows as well as with the normal.

*Figure 30.*

This figure shows two spirals situated in the regions designated by *a* and *b*. In each case the spiral is due to the curving of the furrow near the median line of the body. In the one case the curve is on the dorsal surface, in the other on the ventral. Since the curved furrows are on opposite surfaces and yet nearly parallel, the two spirals are opposite in direction. In both cases the ends of the spiral portions unite more or less completely with adjacent segments, owing to the fact that the furrows between them end free.

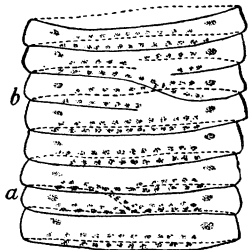


FIG. 30.

In *b* this union is much more complete than in *a*. In *a* the spiral furrow makes two turns about the body, in *b* only one and a half as a continuous furrow. If, however, the partial furrows at the right in *b* be considered as a continuation of it, this furrow also makes two complete turns.

The lateral regions and edges of the segments are all normal in form, and we find all the genital masses normal in position.

*Figure 31.*

The figure is a view from the dorsal side of a series of segments, showing a number of abnormalities. The first of these is the small partial segment *b*, wedged in at the right between *a* and *c*. Its dorsal surface is greater than its ventral, and its edge is nearly as long as that of a normal segment. Dorsally the furrow between *a* and *b* ends free on the surface. The

corresponding ventral furrow turns anteriorly a short distance from the edge and meets the main furrow between *a* and *c*. Thus the ventral surface of *b* is completely marked off from other segments. Both the dorsal and ventral furrows between *b* and *a* are rather shallow. The organs in *b* are distinctly abnormal. A rather small ovary and vitellarium appear nearer the edge than in normal segments, probably because of the increasing length of the segment *b* nearer the edge. The oviduct is incomplete and ends bluntly, as the figure indicates.

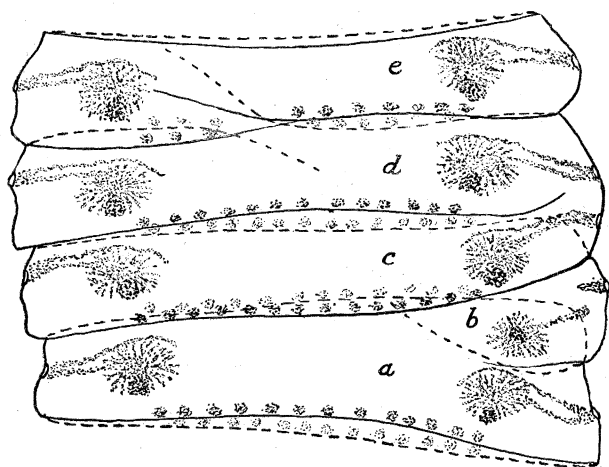


FIG. 31.

A distinct pore is present, and connected with it is a well-developed cirrus, but no trace of a vas deferens is found anywhere in the segment. The position of the various organs illustrates well the relation of each to the form of the segment in the region where it occurs. Thus the ovary and vitellarium, which appear from the dorsal surface to be near the posterior edge of the segment, lie midway between the bounding furrows on the ventral surface, and the oviduct, which extends somewhat dorsally from the ovary, runs obliquely forward towards the edge, so that it is normally placed with regard to the furrows on the dorsal surface. The pore lies near the anterior end of the segment. The ventral furrow bounding *b* anteriorly turns backward before reaching the edge and unites with the

posterior furrow, so that the region corresponding to the ventral side of *b* is cut into two parts, that nearest the edge being united with *c*, *i.e.*, taking *b* as it appears on the dorsal surface, we find that it is not separated from *c* at the edge. As *b* is bounded on the ventral surface it does not reach the edge of the body at all. The position of the pore is evidently connected with these peculiar relations. The dorsal side of *b*, together with *c*, forms a spiral. Beginning with the dorsal partial furrow between *b* and *a*, the spiral furrow makes two complete turns about the body.

The rudimentary condition of the organs in *b* is undoubtedly due to the small size of the segment. The ovary and the oviduct are more completely developed than the vas deferens. The segment *b* contains a number of testes and in some spermatozoa are visible.

The position of the organs in *a* needs no comment. The segment is of peculiar form, owing to the presence of *b*, but its genital organs are normally situated.

The furrows between *c* and *d* are abnormal. The dorsal furrow ends at the right without reaching the edge, and the ventral furrow turns posteriorly near the right edge and meets the posterior boundary of *c*. Thus the right edge of *c* and *d* is not divided by any furrow, but the dorsal furrow extends almost to the edge. The ovary and vitellarium at the right of *c* are normally placed with regard to the ventral boundaries, and the ducts and pore with regard to the dorsal boundaries. Both ducts cross the course of the ventral furrow at an angle to reach the edge, thus indicating that relations on the ventral side have little influence on their direction. At the right of *d* a normal set of organs occurs. The figure shows, however, that the two pores on the right edge of *c d* are near together. In the region of the inner ends of the ducts the segments are completely separated, and the distance between the two sets of ducts is normal here. As they approach the surface, however, the separation between the two segments on the dorsal surface becomes less and less complete, and the edge itself is undivided. Thus the pores tend to form near its middle, but the fact that the dorsal furrow extends so nearly to the edge

indicates that a certain degree of individuality exists up to and perhaps beyond the point where it terminates, and this, together with the length of the edge of *c d*, accounts for the presence of two pores instead of the union of both sets of ducts in a single pore.

Between the segments *d* and *e* the furrows are very abnormal. The ventral furrow is divided into two parts which overlap on the surface, the one turning anteriorly, the other posteriorly. The oblique portions are very shallow and do not bear interproglottidal glands.

The dorsal furrow is also in two parts. The one at the left does not turn posteriorly, but continues as a very shallow furrow over the region corresponding to that which the ventral furrows leave undivided, and finally unites with the right half. This latter, however, continues to the left, beyond this point, but turns anteriorly, running up into the segment and ending just dorsal to the ovary. The oblique portion is shallow, like the oblique portions of the ventral furrow, and bears no glands. The genital organs at the left of *d* and *e* are normal, however, doubtless because the growth has been normal in the regions where the organs occur. Only the oblique portion of the dorsal furrow approaches the ovary, but, as has been repeatedly shown, the position of the ovary is influenced only very slightly, if at all, by the form of the dorsal surface.

*Figure 32.*

At the stage of development shown in the figure the genital masses are becoming differentiated into the various organs. The female portion is mostly distinct from the male, and the strands of cells forming the ducts extend nearly or quite to the edge of the body, though the pores are not distinct as yet. The variation shown is a spiral in which the furrow makes two complete turns, the spiral segment bounded by it making one complete turn. The spiral begins on the right in the short furrow bounding *a* posteriorly and separating it completely from the proglottid behind; from this point it passes around the body, bending forward at the right side of the upper sur-

face to form the anterior boundary of *a*, then making one more complete turn and ending on the upper surface, thus leaving *b* and *c* incompletely separated at the right of the dorsal surface. The development of the genital organs is sufficiently advanced in this case to show the very intimate relation of these organs as regards position with the form and relations of the proglottids. The segment *a* possesses its own genital mass (*a'*), which is entirely separated from all the others. This is, however, of less than the normal size and does not reach the edge of the segment. It is divided into two parts in its inner portion, but the group of cells which would later form the ovary and vitellarium does not appear. In fact, the mass seems to consist largely, if not wholly, of portions of the two ducts. It will be remembered that the ducts lie farther dorsally than do the ovary and vitellarium. The figure is drawn with the dorsal surface uppermost, and it is only dorsally that the region *a* appears as a distinct partial proglottid. On the ventral surface the relations of the furrows are entirely different. It appears then that the dorsal region of *a* possesses a degree of individuality sufficient to cause the appearance of the organs proper to this region. The ventral region not being separated from *b*, the organs of the ventral side do not appear. Whether the organs would in later stages approach or reach the normal development it is impossible to state with certainty, but the evidence seems to be against such a view, for in all cases of similar abnormalities in much later stages the genital organs or parts, however rudimentary they may be, show the same degree of differentiation as those of normal segments.

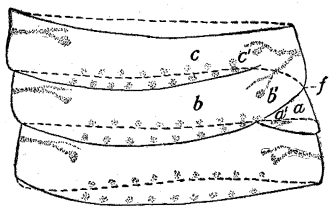


FIG. 32.

In the large, incompletely separated segments *b* and *c*, there appears another example of the close relation between the individuality of the segment and the presence and arrangement of the reproductive organs. At the left appear normal sets of organs in normal position. At the right, however, where the furrow on the dorsal surface is incomplete and that upon the

ventral surface bends posteriorly, two sets of organs ( $b'$  and  $c'$ ) appear whose ducts open into a common genital pore. Each of the sets is apparently complete, possessing the groups of cells which will form ovary and vitellarium, as well as the vas deferens. The inner portions of these two sets are situated much as they would be if  $b$  and  $c$  were normally separated from each other, *i.e.*, their position is nearly normal. The partial furrow on the dorsal surface, however, does not extend to the right edge of the body, but ends free before reaching it, so that  $b$  and  $c$  are united here, and correspondingly only one genital pore appears at  $d$ , and into this both sets of ducts open. But the question now arises as to the reason for the connection of the organs  $b'$  with this pore. Normally these organs would open on the edge at some point not far from  $f$ , but, owing to the arrangement of the proglottids in this case,  $f$  is the point of intersection of the furrows, *i.e.*, does not possess the features of the region where the genital pore normally appears, for this is upon the edge, about midway between two furrows. The only possible conclusion from the facts is that the direction of the ducts and their final connection with the pore are correlated with the form of the proglottids in this region and especially upon the dorsal side. This conclusion is confirmed by the fact that the ducts cross almost at right angles a furrow on the ventral side, thus rendering it evident that their arrangement is not affected by its presence. In short, ovaries and vitellaria arise separately in  $b'$  and  $c'$ , because the relations of the ventral sides of the segments in that region are practically those which exist in two separate proglottids, and upon the dorsal surface the same is true in the immediate region of the inner portions of the organs. Nearer the edge, however, the relations on the dorsal side are those of a single segment, so that the two sets of organs approach each other and finally open in a common pore, which occupies a normal position with respect to the boundaries of the proglottid in its immediate vicinity.

*Figure 33.*

This figure shows a rather long spiral, together with a small completely separated partial proglottid. The furrows bounding the spiral begin between the partially separated segments *a* and *b* near the left side of the dorsal surface — the dorsal surface is uppermost in the figure — and make a little over three turns about the body. At the left side of the dorsal surface, between the segments *d* and *e*, the furrow becomes shallower, and on the left edge it terminates. The spiral segment enclosed by it makes a little more than two complete turns. In consequence of the course of the furrow, *a* and *b* are incompletely separated on the dorsal surface, but completely separated ventrally; the furrows bounding the regions *b*, *c*, and *d* do not correspond on the two surfaces, and finally *d* and *e*, which are distinct dorsally, are completely united on the ventral surface. These abnormal relations are accompanied by a number of corresponding abnormalities in the genital organs. At the left side *a* is distinct from *b*, and the genital organs *a'* on this side are normal and in normal position. At the left side of *b*, *c*, and *d*, where the spiral character of these segments becomes evident, the genital organs show marked abnormalities. At *b'* only two small groups of cells are found, representing apparently portions of the ducts; at *c'* and *d'* full sets of organs occur, but lie obliquely, and the ducts are elongated. It is evident that the pores and the greater portions of the ducts are normal in position with regard to the dorsal form relations of the segments. The oblique direction of the ducts is apparently due to the fact that the dorsal side of *c* and *d* bends forward near the left edge. Since the inner portions of the organs are formed at the normal distance from the edge, in order to reach the edge as they do, the ducts must be longer than the normal, for they must run obliquely.

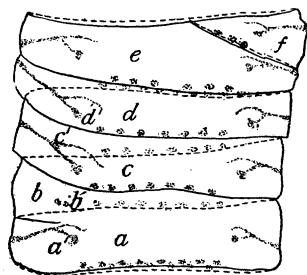


FIG. 33.

The dorsal sides of *b* and *c* both correspond in part, as

regards position, to the ventral side of *b*. The ovary of the set *c'* lies in *b* as bounded ventrally. Apparently the dorsal side of *c* and the ventral side of *b* are to be regarded as belonging together at the left, even though they do not occupy corresponding positions, as they do at the right. If this be the case, the organs *c'* show a close correspondence to the form relations. Upon the dorsal surface *b* is merely a small portion, intercalated, as it were, between *a* and *c* and incompletely separated from *a*. The genital organs are very rudimentary. The ventral organs found in *b* belong to the set *c'*, and there is no distinct ventral region corresponding to the dorsal side of *b*. Thus no ventral organs appear. Two small groups of cells (*b'*) are the only traces of genital organs in this region. These apparently represent portions of the ducts. This very slight development of genital organs is probably due to the small size and imperfect form of this portion.

The set of organs at *d'* shows much the same relations as that at *c'*. Its pore, however, is very close to the furrow between *d* and *e*, as is also the pore of the organs at the left of *e*, which are otherwise normal. The approximation of these pores is evidently correlated with the incomplete separation of *d* and *e* by a shallow furrow on the dorsal surface, and not at all ventrally.

On the right, at *f*, a small partial segment is separated from *e* by oblique furrows. It possesses a normal set of genital organs. The intercalation of *f* leaves the right edge of *e* very short, but the genital organs are, so far as appears, normal. Whether they will reach full development and normal size cannot of course be determined.

*Figure 34.*

The abnormalities figured here occur not far behind the scolex, where genital organs have not yet appeared. At *a* there is a small partial segment wedged in between two others at the left side. Just anterior to this is a spiral, beginning on the lower surface and making nearly two turns. The course of the spiral furrow is such that on the upper surface the segment *c* does not reach the left edge at

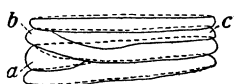


FIG. 34.

all, and on the lower surface the segment next to *a* narrows toward the left and ends at the edge.

*Figure 35.*

The figure shows a complex case of partial division (*a*) and a spiral of about four turns (*b c*). The region *a* is partially separated into two segments at the right, but at the left into three, the most anterior (*b*) forming the beginning of the spiral. On the lower side, just beneath *b*, there is a small region wholly marked off by furrows and not forming part of the spiral. The spiral *b c* is perfectly simple in form, though rather long. This case, like Fig. 34, was found near the anterior end of the chain, and neither genital organs nor inter-proglottidal glands are formed.

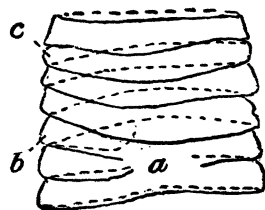


FIG. 35.

*Figure 36.*

The figure is a dorsal view of an extremely long spiral, which makes seven complete turns about the body. The spiral is due to the bending posteriorly of the ventral furrows near the right edge.

At the left the segments are all normal in form, and all of the genital organs are normally placed. At the right the curve in the ventral furrows produces complex relations in the various segments. All of the curved portions of the ventral furrows except the one anterior to *c* are much shallower than the transverse parts, as is indicated in the figure. In the one exception, the furrow anterior to *c*, the curved portion appears as distinct and deep as the rest of the furrow. In *a*, *b*, *d*, *e*, and *f* the inner portions of the organs of the right side are seen to lie in about their normal positions with respect to the boundaries of their segments. The ducts are parallel to the dorsal furrows and cross the course of the ventral furrows in each case, *i.e.*, they conform to the relations on the dorsal side. In the segment *c*, however, the ducts run nearly parallel to the



the ducts in the other segments of the spiral, is undoubtedly determined by the relations existing here. Probably the small size of the dorsal side of *c* at the right is the real basis of the difference, for it is largely because of this that the ventral side of *c* is so intimately connected with *b* at the right.

The segment *g* is nearly normal in form in the region of the right ovary, and this lies in its normal position. Nearer the edge, however, the dorsal and ventral sides of the segment do not correspond, the ventral surface bending posteriorly, while the dorsal bends slightly in the opposite direction. The ducts and the pore evidently conform to the relations on the dorsal side, but they lie almost directly over one of the ventral furrows.

*Figure 37.*

This case comprises a number of segments which show an approach to the spiral form but do not quite attain it, since most of the furrows are not complete at the left. The figure is a dorsal view. It can easily be seen from the figure that if the furrows on the two surfaces were continued over the left edge, a spiral segment extending through the whole series would be formed. The manner in which a spiral arises is well illustrated by this case. The bending of the furrows near the edge on one surface is all that is necessary. Here the dorsal furrows bend anteriorly, while the ventral furrows remain straight, except between *a* and *b*, where there is a slight posterior curvature.

At the right the segments are all normally bounded, and the genital organs of the right side are normal in form and position. At the left, however, where the relations approach the spiral form, the organs show corresponding abnormal relations. At the left of *a* the anterior ventral furrow is normal in the ovarian region, but turns posteriorly near the edge, and the dorsal furrows bend anteriorly, so that the dorsal side of the segment appears curved forward at the left end. The ducts and pore show clearly the influence of this form. The course of the ducts toward the edge is oblique, *i.e.*, nearly parallel to the dorsal furrows in this region, and the pore lies nearly

in the middle of the edge as it is bounded dorsally. In *b* very similar conditions exist, but the bend in the dorsal surface of the segment is more pronounced than in *a*. The ducts are more oblique than in *a* and elongated, but preserve the same relations to the segment. The dorsal furrow forming the anterior boundary of *b* curves to such a degree that it does not reach the edge at all, thus leaving it apparently undivided, *i.e.*, not distinct from the edge of *c*. Near the middle of this common edge a single pore appears, and into this open the

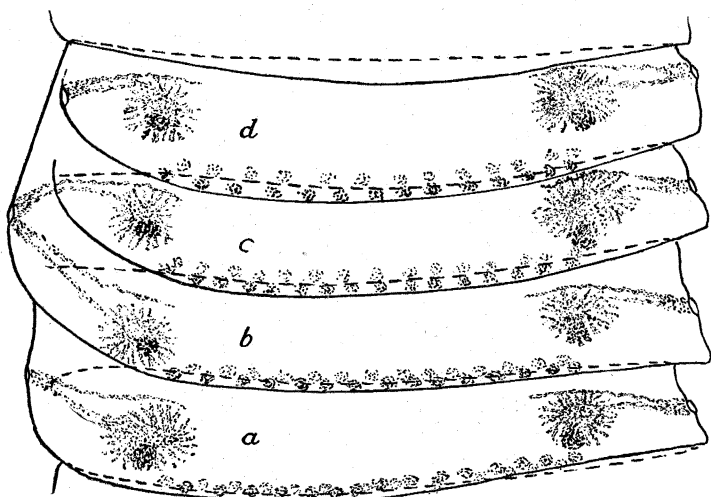


FIG. 37.

ducts from *c* as well as those from *b*. The ducts of the organs in *c* cross the course of the curved dorsal furrow to reach the edge, but this part of the furrow is very slight.

The organs at the left of *d* present an extremely interesting relation with respect to the furrow. The dorsal furrow between *c* and *d* turns anteriorly and runs parallel to the edge, but the furrow in front of *d* is straight. The ducts of the genital organs show no tendency to run parallel to the curved furrow, but meet it almost at right angles, and the pore appears in this furrow instead of upon the edge of the body. The furrow is deeper than the one posterior to it which crosses the ducts in *c*, apparently without affecting their position.

The difference in the relations in these two cases is undoubtedly due to the difference in depth of the two furrows. In the case of *d* the furrow is deep enough either to interrupt the course of the ducts or else to produce conditions approaching those at the edge of the body, and consequently the pore forms here instead of at the edge. The ducts are slightly shorter than the normal, but the inner portions of the organs show a perfectly normal arrangement.

## 2. *Other Abnormalities.*

Under this head are included a few cases of abnormalities of a different nature from those previously described. Two of these (Figs. 38 and 39) are cases of lateral duplication of the genital organs, and the other two (Figs. 40 and 41) are cases of alteration in position of the genital organs.

### *Figure 38.*

The figure, a view from the ventral side, shows a number of abnormalities. Between the segments *a* and *b* the furrows are normal except near the right edge, where both curve posteriorly. On the ventral surface the furrow ends before reaching the edge, while dorsally it continues to the edge. The inner portions of the genital organs are normal, and the ducts extend in the normal direction toward the edge, but do not reach it. The pore lies on the curved dorsal furrow a short distance from the edge of the body, *i.e.*, on the dorsal surface. The terminal portions of the ducts are entirely normal in structure. Thus the abnormal edge formed by the curved furrow affords conditions which allow a normal pore and terminal organs to appear and so resembles closely the segment *d* in Fig. 37, except that there the furrow between *c* and *d* turns anteriorly instead of posteriorly. At the left of *a* the form of the segment and the organs are normal.

The segments *b* and *c* are incompletely separated on the ventral surface, and *c* is a spiral in consequence of the peculiar curve of the ventral furrow separating the parts *c* and *d*. On

the dorsal surface the furrows are normal, and the regions corresponding to *c* and *d* are parts of a single segment. Thus the spiral furrow bounding *c* and *d* begins ventrally between *b* and *c*, makes one turn, then bends anteriorly, separating *c* and *d*, next makes another almost complete turn and finally ends on the ventral surface anterior to *d*, so that *d* is not completely separated from the segment next anterior to it.

At the right of *b* the edge is very long in consequence of the curve in the posterior furrows, but there are indications that these curved portions of the furrows do not mark the

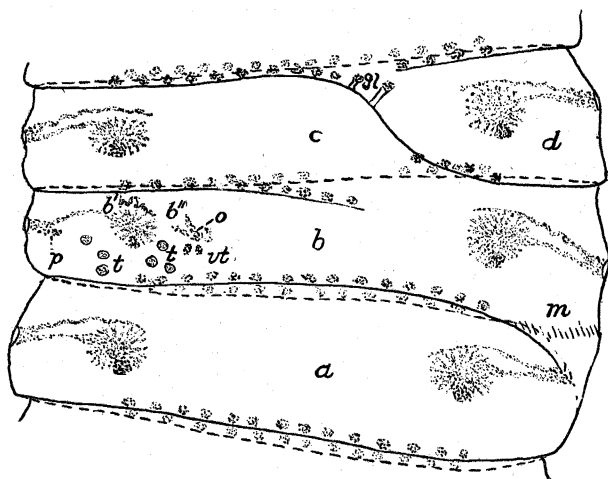


FIG. 38.

actual posterior boundary of *b*. Along the line *m* the cellular structure appears denser and stains more deeply, thus resembling in appearance the regions near the intersegmental furrows. There is no real furrow here, but the presence of this band of tissue similar to that which occurs along segmental boundaries indicates that the posterior boundary of *b* is here and not along the curved furrows; that is, these latter are mere wrinkles in the surface continuous with the intersegmental furrows. If this be the correct interpretation of the conditions here, it is evident that the ovary and pore at the right of *b* present the usual correlation in position with the form of the segment.

At the left of *b* peculiar conditions appear. Besides the organs (*b'*) in the normal position there is another partial set (*b''*) lying to the right of the first. The first set, although normally placed, is imperfect, for the ovary and vitellarium are rather smaller and less branched than usual; the oviduct, atrium, and pore are normal, but the vas deferens is not complete. Its inner end appears anterior to the ovary — near the letter *b'* — but it ends blindly posterior to the oviduct instead of in its normal position anterior to it. A peculiar condition appears in five or six of the testes (*t t*) near the edge. They are enlarged and packed full of spermatozoa, so that they stain like the vas deferens of this stage and are quite different in appearance from the other testes, though the testis cells can be distinguished in them with high powers. The inner portion of the vas deferens is also full of spermatozoa, but the seminal receptacle is empty, indicating that there is no outlet for the sperm into the female organs. In the normal organs of adjacent segments impregnation has already occurred. The accumulation of sperm in the testes (*t t*) is doubtless due to the imperfect development of the male ducts. The movement of the spermatozoa from the middle regions of the segment toward the edges having occurred as far as possible — the testes in the middle region are empty of sperm — they have accumulated in a number of testes near the edge and remain there, since there is no outlet to the exterior or to the female organs. This condition is found in one other case (Fig. 39).

The small size and imperfect development of the set of organs *b'* is probably due to the fact that the left half of the segment *b* is considerably shorter than the normal. The normal length at this age is about that of *a*, and this portion of *b* is only a little more than half as wide as *a*. At the right *b* is wider and normal organs occur.

The second set of organs (*b''*) is very small and rudimentary, consisting of a small simple ovary (*o*) and two small groups of cells representing the vitellarium (*vt*) without any traces of ducts. The orientation of these organs in the proglottid is apparently normal.

This transverse duplication of the female organs does not

appear to be connected with any visible abnormalities in the form of the segment or in the relations of its boundaries. The two sets of organs taken together probably do not represent more material than a single set of normal size. The left side of the segment *b* is somewhat shorter than normal, but in Fig. 39, *c*, where a similar duplication occurs, the segment is of very nearly normal length. The furrows bounding this region of the segment seem to be normal, except that the distribution of the inter-proglottidal glands in the dorsal furrow between *b* and *c* is rather irregular. None appear in this furrow in the middle region of the body, and only a few to the left of the middle. The furrow is normal in appearance, however, and the other furrows seem to be normal in every respect. The conditions found here may perhaps be due to the splitting of a single genital mass in earlier stages, but if this is the case no clue is afforded as to the cause of the splitting. If such a division should occur, later growth would undoubtedly increase the distance between the two portions. From a study of the early stages of the genital organs and their method of origin I am inclined, however, to believe that this extra set has arisen *in situ* and without connection with the set *b'*. If this is the case its appearance must be the result of certain internal conditions, which present no other visible manifestation.

This transverse duplication of organs constitutes a problem entirely different from that of their multiplication longitudinally. Whether or not it is to be regarded as the result of a kind of longitudinal division of the segment is doubtful. No organs except the ovary and vitellarium are duplicated in this case, *i.e.*, the organs on the ventral side only. This is likewise the case in Fig. 39. These two examples are the only ones of this nature which I have found so far, but it is hoped that additional material bearing upon this point may be discovered and may serve to throw some light on the factors concerned in the production of this peculiar abnormality.

The regions *c* and *d* of the ventral side are separated by a portion of the spiral furrow which runs almost longitudinally. At the right it forms the posterior boundary of *d*, but turns anteriorly and then continues as the anterior boundary of *c* at

the left. On the dorsal surface the furrows appear normal. Relations at the two edges are apparently normal, and the genital organs appear normal in all respects.

The relations of the inter-proglottidal glands to the abnormal furrows are interesting. Those portions of the furrow which run transversely show the glands in their usual position, but there are none in the region where the furrow departs from its transverse course. Two of the glands (*g'*) in the partial segment *d* present very peculiar relations to the furrow. Here the furrow bends posteriorly, but the last two glands appear at some little distance anterior to it and almost in line with the others and are connected with the furrow by distinct ducts of considerable length. In the posterior region of the curve two of the glands lie posterior to the furrow as it curves forward, but these open directly. The relation of the glands to this curved furrow affords further evidence in favor of the conclusion that the curved furrows do not always coincide with segmental boundaries. Here the glands do not follow the furrow in this curve, but lie at some distance from it and are entirely absent from that portion which departs farthest from the normal condition. It appears as if the glands follow the line of the real boundary, while the furrow does not. Nevertheless, as the presence of the ducts indicates, the glands tend to open in the furrow.

*Figure 39.*

The series of abnormalities occurring in the three segments represented here is in some respects the most peculiar that I have found in this species. The figure is a ventral view.

In the segment *a* the relations on the right are normal, but on the left there appears on the dorsal surface the anterior end of a spiral, the remainder of which is not drawn, as it makes only one turn and is similar to others already discussed. The ducts of the organs *a'* extend to the surface in accordance with the relations on the dorsal surface and thus open at a point on the edge which is dorsally a part of *a*, but ventrally in another proglottid.

The segment *b* is abnormally short, even more so dorsally than on the ventral surface. In accordance with this fact only partial organs are developed right and left (*lb'* and *rb'*). Ducts connecting with the surface do not appear at all, and on the left no pore is formed. On the right edge, however, a pore appears, of normal size and with atrium and a small portion of the oviduct extending inward from it. This portion was found upon examination to present the characteristic appearance of the oviduct and to possess a lumen, but was

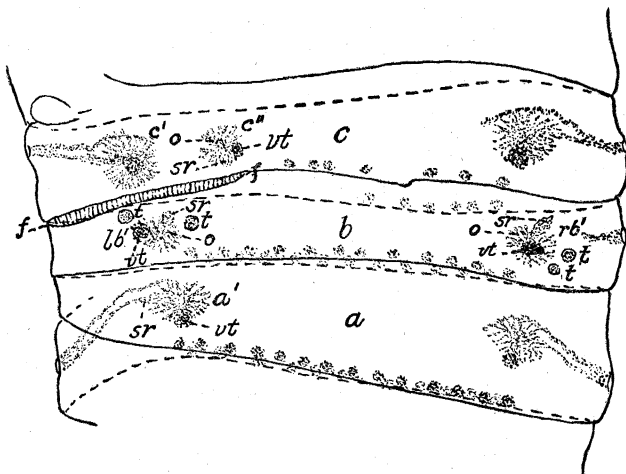


FIG. 39.

closed at the inner end. The reason for the appearance of a pore on the right edge and not on the left lies, I believe, in the fact that the right edge is longer than the left and thus presents more nearly the conditions of the normal edge. Each of the partial female organs *lb'* and *rb'* consists of a small ovary (*o*), a small vitellarium (*vt*), and the inner portion of the duct, terminating in a small, bladder-like, closed seminal receptacle (*sr*), which is empty. The organs of the dorsal surface are less nearly normal than those of the ventral. Testes appear, but their number is much less than the normal, even in proportion to the small size of the proglottid, for they are scattered very sparsely through the middle region, while other segments of this stage show large numbers of them. No traces of vasa

deferentia appear on either side. This rudimentary condition of the male organs is doubtless due to the extreme shortness of the proglottid. As on the left side of *b* in Fig. 38 the spermatozoa have accumulated in some of the testes in the lateral regions of the segment (*t t*). In this case there is no exit on either side of the spermatozoa, and the female ducts are incomplete and unconnected with the male ducts. Consequently the segment is not functional. The spermatozoa cannot fertilize the eggs of this or any other segment, and the eggs cannot be fertilized by spermatozoa from this segment or from any other.

The ventral furrow between *b* and *c* is distinctly abnormal, especially at the left. A normal furrow does not cut into the body vertically, but obliquely, and in such a manner that the posterior edge of each proglottid seems to overlap the anterior edge of the next succeeding. Over about two-thirds of its course the ventral furrow between *b* and *c* is normal in its relations, though slightly irregular in its course. Over the remaining third, however, — the shaded portion at the left marked *f*, — it is a vertical furrow widely open to the surface, and nearly twice as deep as the normal furrow by actual measurement. It cuts almost halfway through the body and thus separates *b* and *c* in this region much more completely than they are separated elsewhere. This portion of the furrow shows no inter-proglottidal glands, but they are present in the more nearly normal portion. The ventral furrow anterior to *c* is also abnormal at its left end. It is interrupted, one portion turning anteriorly, and the other curving near the edge so as nearly to enclose a small area. The dorsal furrow bounding *c* is normal.

In the segment *c* there are two normal sets of organs, the one situated normally, and the other nearly so ; but in addition to these organs a third set (*c'*) appears situated to the right of *c'* and consisting of a small ovary (*o*), a vitellarium (*vt*), and a small, empty seminal receptacle, which is closed. This case of transverse duplication of organs is very similar to the one figured in *b* in Fig. 38, and it is in the same region of the body, the two being separated by some thirty segments only. This second case does not afford any evidence as to the factors concerned

in the production of this form of variation. However, the position of the organs in *b* and *c* does bring to light some interesting facts regarding the orientation of the organs in the segment, indicating that this also is perhaps correlated with the "form" of the segment.

In the normal form of the female organs the vitellarium lies more or less completely posterior to the ovary, as is clear from many of the figures (see *a'* in segment *a* of this figure, for instance). The seminal receptacle appears at a point separated from the vitellarium by one-quarter of the circumference of the ovary, *i.e.*, about ninety degrees (note the position of *vt* and *sr* in *a'*, where they are normally situated). Now in the supplementary set of organs *c''*, in the segment *c* the vitellarium lies on the right side of the ovary, while the small rudimentary seminal receptacle (*sr*) is posterior. That is, the whole set of organs appears as if rotated through an angle of ninety degrees from its normal position. An oviduct, if present and normally oriented with respect to the ovary, etc., would lead to the shaded portion of the furrow *f*.

Turning now to the organs *lb'* at the left side of *b*, we find that the parts present in this set are the same as those found in *c''*, *viz.*, a small ovary (*o*), a vitellarium (*vt*), and a small closed seminal receptacle (*sr*). The orientation of this group, however, is different from that of *c''*. The vitellarium, instead of being in its normal position posterior to the ovary, lies at the left of it, while the small seminal receptacle (*sr*) is anterior to the ovary, instead of to the left. Here, then, the whole complex appears as if rotated through an angle of ninety degrees in the direction opposite to that in which the rotation of *c''* is conceived as having occurred. In consequence of this position, an oviduct, if present and oriented normally with respect to the other organs, would, as in the case of *c''*, open into the shaded portion of the furrow *f*.

Examination of the organs *rb'* at the right of the segment *b* shows that the relations there are more nearly normal. The vitellarium (*vt*) is somewhat posterior to the ovary, and the seminal receptacle, *sr*, though somewhat more than ninety degrees from the vitellarium, does extend in a nearly normal

direction, and if growth of the parts continued, the receptacle and the oviduct from the pore would meet. In brief, this set of organs shows what is practically the normal orientation, while  $lb'$  and  $c''$  do not.

The suggestion which offers itself in this connection is that the abnormal orientation of the organs  $c''$  and  $lb'$  is correlated with the presence of the furrow which lies between them. The furrow is on the ventral side, as are these organs. May it not be possible that the orientation of these two sets of organs with respect to this furrow is due to its extreme depth? They are oriented with regard to it as if it were the edge of the body, though no pores appear, opening into it. There is a considerable extent of free surface in the dorso-ventral plane on the sides of the furrow. The organs at  $c''$  are far from the real edge, but near this abnormal furrow, and their abnormal orientation appears to be a form of adaptation to the abnormal conditions. The complex of organs  $lb'$ , as described, is correspondingly oriented with regard to the furrow  $f$ . The question at once arises as to why this should be, since this set lies at the normal distance from the real edge. The answer to this question may lie in the fact that the left edge of the segment  $b$  and the region near it are very short — apparently too short to allow a pore and ducts to appear. The organs at  $lb'$  are much nearer to the furrow  $f$  than to the edge, and if the orientation of  $c''$  is determined by the furrow, that of  $lb'$  may be also. In the organs  $c'$  orientation and position are apparently normal. The pore lies rather far anteriorly, and this is probably due to the fact that  $c$  is incompletely separated dorsally from the segment next in front. The position and orientation of this set of organs may seem to be strong evidence against the conclusion that the orientation of  $c''$  and  $lb'$  is due to the presence of the furrow  $f$ ; but here the edge is normal and the proglottid is of normal length, *i.e.*, normal relations are possible here, while they are not in the cases of  $lb'$  and  $c''$ . Furthermore, on the right of  $b$ , where the furrows are both normal, and the edge is wider than at the left, the organs are normally oriented and a pore is present, though the parts are not connected.

All who study the cases discussed in this and the preceding paper must, I believe, conclude that the position and arrangement of the genital organs in abnormal as well as in normal proglottids are very definitely determined by the form relations

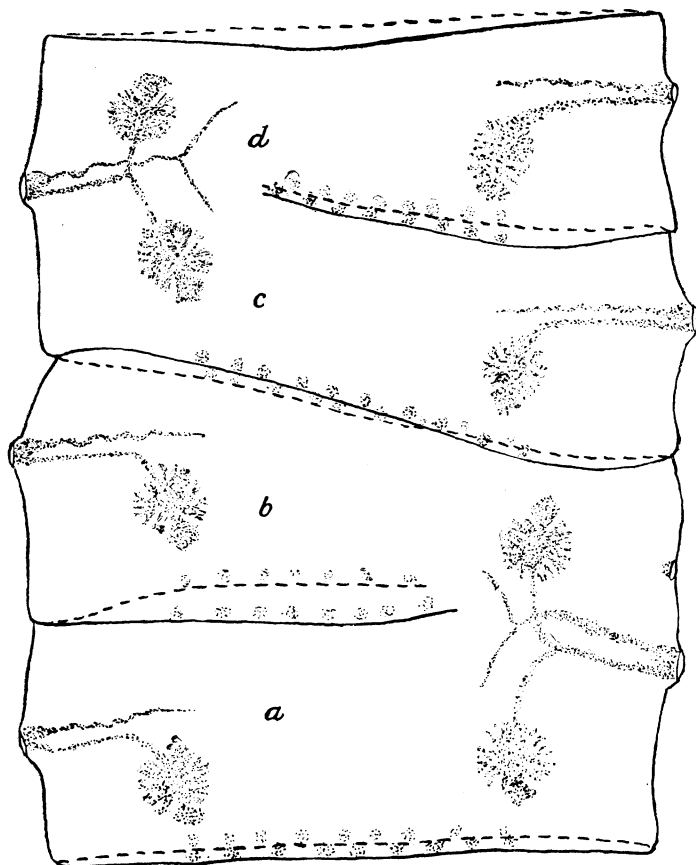


FIG. 40.

of their segment. The above suggestions have been made in the belief that the form relations may have some influence here, and in the hope of throwing some little light on the conditions in this particular case. Whether other similar cases, if found, will confirm them remains to be seen.

*Figure 40.*

Two cases of partial division are figured here as seen from the dorsal surface. The two are almost exactly similar, except that in one case the partial furrows extend from the left edge, in the other from the right. At the side of the body, which is completely divided in each case, two complete sets of genital organs normally situated are found. At the other side the inner portions are double, but the ducts unite to form a single

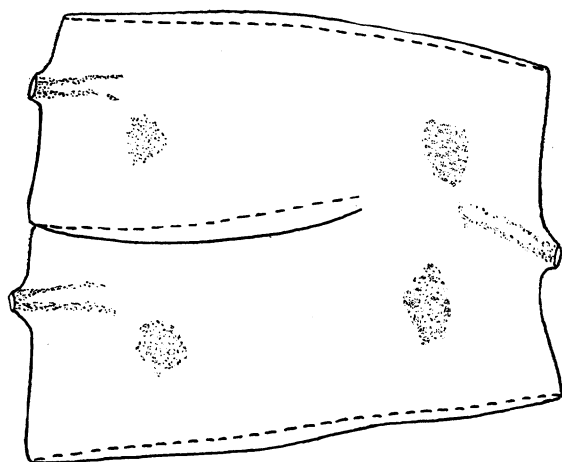


FIG. 41.

vas deferens and a single oviduct, and these open through a single pore, which is situated almost exactly in the middle of the undivided edge. The most remarkable fact is that the position of the anterior set is the reverse of that of the posterior set in each case, the oviduct running posteriorly from the ovary, and the vitellarium lying anterior instead of posterior to the ovary. The vas deferens also runs posteriorly instead of laterally. The arrangement of the organs is very evidently correlated with the incomplete separation of *a* and *b* and of *c* and *d*. The undivided edges of *a b* and *c d* are shorter than the divided edges, but the undivided edge of *a b* is longer than the undivided edge of *c d*, and it is interesting to note that in the region corresponding to *b* of the edge *a b* a second pore appears,

much smaller than the one posterior to it and without any ducts opening into it. Apparently the greater length of this edge has afforded space, as it were, for the formation of another pore, but the ducts connecting with it fail to appear. This case, like a number of others, shows that the pore may be wholly unconnected with the other organs, but that its formation is doubtless due to the general conditions that lead to the formation of the other portions of the set, even though the two parts do not unite.

*Figure 41.*

This case is very similar to the one shown in Fig. 40. The development is so far advanced that it is impossible to determine with certainty whether the division of the ducts is as complete as in that case. The cell-masses at the right representing the two ovaries and vitellaria appear about equal in size, and there are indications that they were connected with the single duct leading to the pore. It is impossible to determine whether the vas deferens divides or not.

HULL ZOÖLOGICAL LABORATORY,  
UNIVERSITY OF CHICAGO,  
May, 1900.